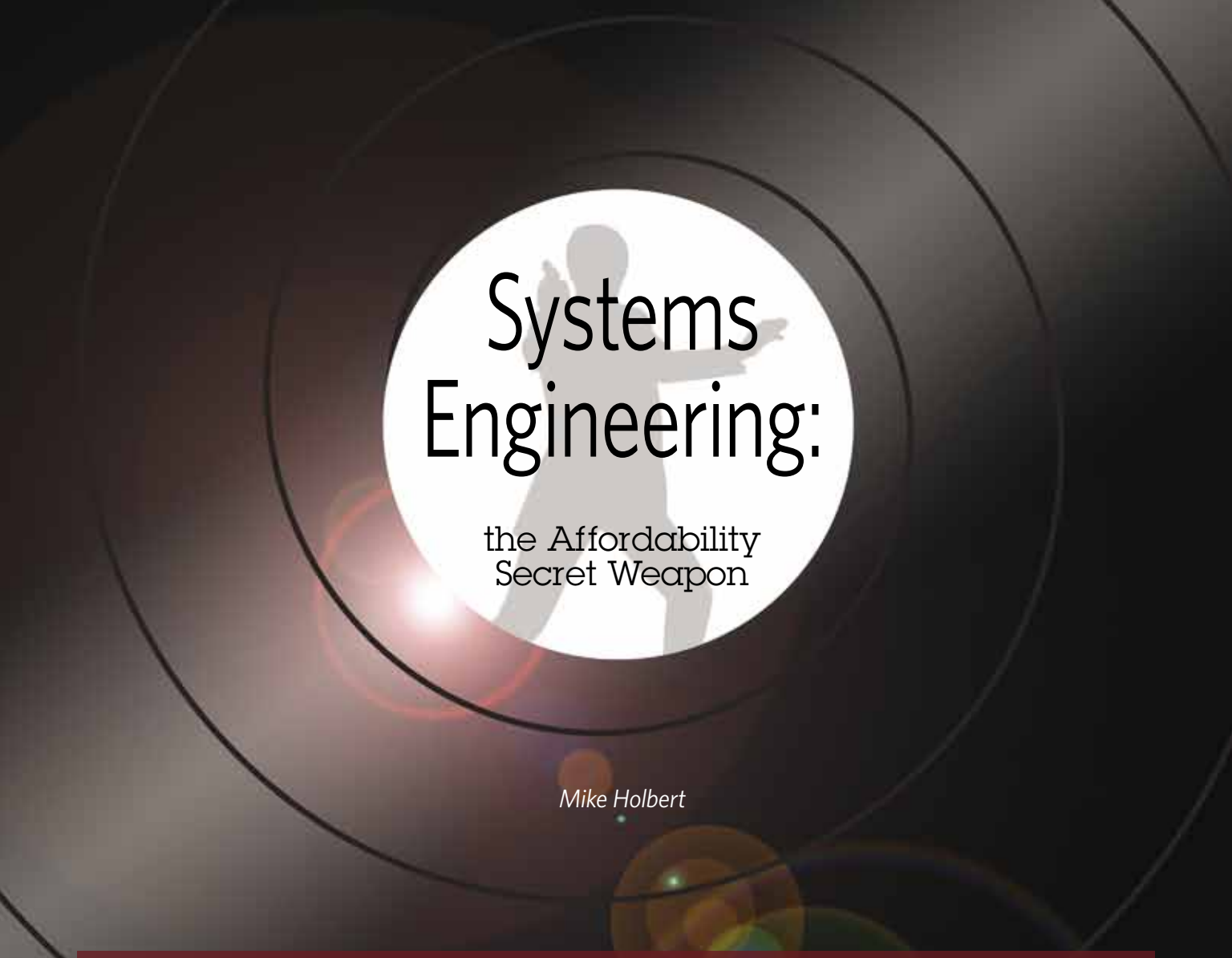

Systems Engineering:

the Affordability Secret Weapon

Mike Holbert

While Dr. Carter's affordability initiatives highlight the role of program managers in creating program affordability, a closer review shows a majority of program efficiencies can result from implementing program rigor through effective systems engineering, or if you prefer, systems thinking. How so?

It's the system engineering process that:

- Breaks down the requirements into understandable/actionable units for analysis, establishing system, subsystem, and component qualities and capabilities.
- Provides the analysis leading to design solutions via detailed designs and/or processes and procedures.
- Provides the analysis to make supportability decisions years before the end item is even tested.
- Identifies the technical roles and the potential solutions which become the basis for the Acquisition Strategy.
- Ensures alignment of requirements, specifications, and statement of work.
- Generates the decision-quality information to drive the effort to completion.
- Ensures an integrated and interoperable system from beginning to end.

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While I could go on about the advantages of a disciplined systems engineering approach, the real challenge is not in simply identifying how it ought to work, but in delivering affordable performance through consistent, persistent intellectual focus and action.

Common to many of the 23 affordability initiatives is the implied use of disciplined processes to enable disciplined decision making at all levels, using appropriate data. To aid this leadership/management function, there are eight systems engineering technical management processes to help provide intellectual focus and tracking of actions:

- Decision analysis: the deliberate process for making optimum decisions
- Technical planning: defining the scope of the technical effort required to develop, field, and sustain the system
- Technical assessment: the process of reviewing, analyzing, and evaluating a series of technical products to determine effectiveness in meeting the systems capability requirements
- Requirements management: assuring traceability of allocated and derived requirements to the user defined capabilities
- Risk management: identification, analysis, mitigation, and tracking of root causes that impose a probability you will not meet cost, schedule, or performance requirements
- Configuration management: identifies, documents, audits, and controls the functional and physical characteristics of the system design
- Data management: the process to acquire, access, manage, protect, and use data to support the product throughout its life
- Interface management: control measures and processes to document and communicate physical and functional attributes of a product or system

Each of these systems engineering technical management processes is further described in chapter 4 of the *Defense Acquisition Guidebook*. When properly executed, these technical management processes allow clear insight into, and control of, the technical processes used to develop and field a capability. The technical processes are espoused in the various versions of the systems engineering "Vee" model and the newer "Comprehensive Systems Engineering Process (CSEP)" model. However, a dilemma exists with any model used; models do not and cannot assure disciplined processes are executed, or disciplined decision making is followed. Sorry to say, yes, this dilemma does apply to the beloved engineering "CSEP," "Vee," the older "Engine," and even the "Affordable System Operational Effectiveness" models.

This is where the joint leadership by the program manager and systems engineer (a PM's technical conscience) must ally with each other to pre-think and pre-plan driving process and decision discipline, and thus affordability. These eight technical management processes provide the context for the rest of this discussion. They apply to the program manager and other key stakeholders, both up and down the decision chain.

Start Well by Knowing Your Destination

The purpose of any systems engineering model is to help the program manager and the program team understand activities and logical decision points as the effort progresses. Due to the structured nature of the systems engineering process and the checks and balances of the eight technical management processes, a program manager can make informed decisions at the beginning of a program and throughout its life cycle to determine which requirements lead to the greatest affordability dividends. To understand how this works, let's look at the "Hierarchical Systems Engineering Vee" model (Figure 1). In the Requirement Definition process, senior decision makers must focus on these critical questions:

- What is the capability or function of the program or product?
- How much are we willing to pay for each product, "a worth" determination?
- Is the solution "affordable?"
- Does the schedule meet the need as well as the "investment plan"?
- What is the expected level of "process conformance" by the program?

This requirements definition activity starts the systems engineering effort in development planning and arguably engages most of the eight technical management processes. To better understand the critical nature of the requirements process, and its impact on affordability, refer to Jack Mohney's article on the effective development of joint operational requirements.

As you move toward the Requirements Analysis activity, planning becomes the program manager's most critical task. Enter the systems engineer as the program manager's specific ally, along with some other close allies like their contracting officer, financial manager, logistics manager, and their human resources manager.

Personal Involvement Matters

As we survey the rest of the "Vee" by moving through the three Decomposition and Definition activities, Implementation, and the three Realization and Assessment activities, it causes us to invoke disciplined planning. This is underpinned with risk management, technical assessment, requirements management, interface management and with a critical dose of decision analysis. Four foundational documents provide the articulation, for all to see, of how you will exercise the eight technical management processes to invoke consistent, persistent intellectual focus and action. These documents are the Acquisition Strategy (AS), System Engineering Plan, Life Cycle Management Plan, and the Test and Evaluation Master Plan. Each plan should flow from the AS and expound on how the eight technical management processes will be used to deliver decision-quality data and ultimately the desired capability.

These planning documents are much too important to simply outsource or "borrow" from another document. A program manager's personal involvement will have dramatic affordability impacts—positive or negative. The program manager must chart the program course through critically constructing an AS foundation and laying out appropriate plans to execute the strategy. By doing so, the program manager moves every aspect of the program, and every person involved, in a common direction and a common rhythm.

The Play Book

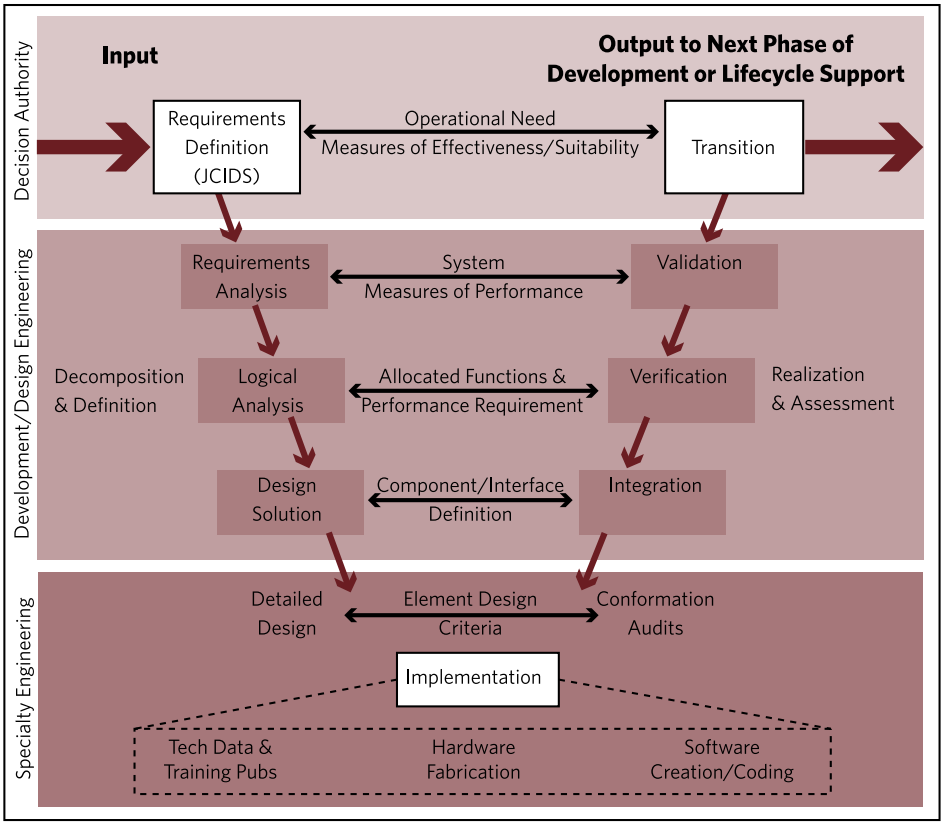
The AS is the program manager's and team's self-developed program "git-'er-done" play book and must start by answering the question: "What are the program risks based on a clear understanding of the defined requirements and concept of operations?" The trick is articulating those risks and mitigating them using the AS through:

- Describing the capability being procured and the associated risks.
- Justifying contract type(s) and associated incentives.
- Stating funding types and timing for the various types.
- Detailing conformance to agreed to processes.
- Establishing technology understanding/maturity and trade study expectations.
- Stating how the system is planned to be sustained or discarded.
- Determining how to demonstrate the product works (as the requirements have been defined).
- Including the impact of either a joint or international partner.

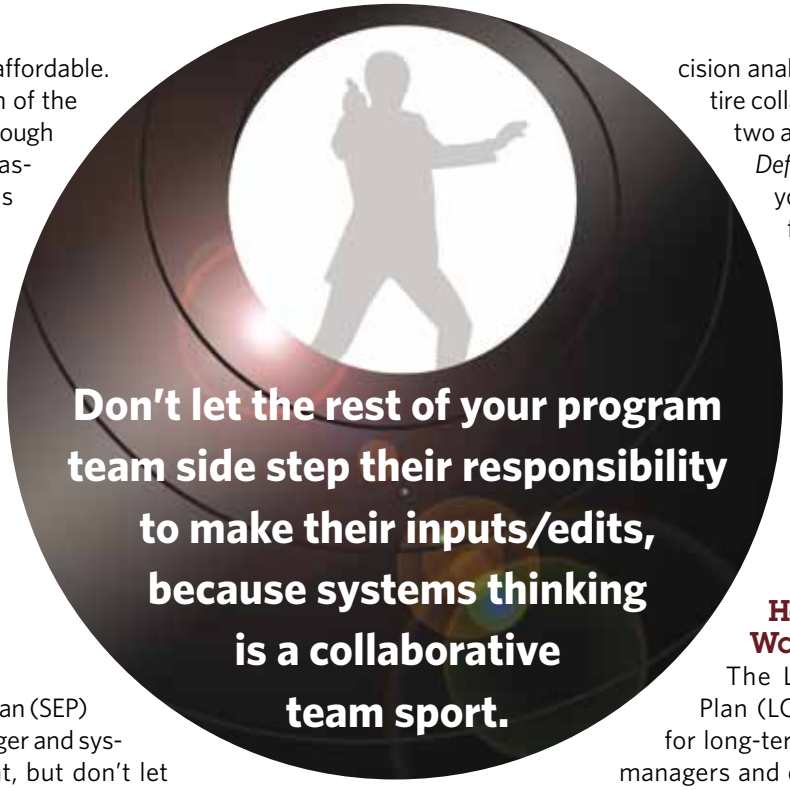
Perhaps the three most important aspects that create the overarching business strategy in your Acquisition Strategy are contract types/incentives, funding types/timing, and the integrated master plan and the associated program integrated master schedule, which may not simply be the contract schedule. To better understand the options available to the program manager in his business strategy, I refer you to the article by John Pritchard, et al., discussing how new contracting approaches impact program affordability. Affordability is and, frankly, has always been an ever-present concern, but it has for the most part been "talked around" in the AS.

So the recurring theme in planning discipline is to state clearly how each part of your AS will work to keep the total

Figure 1. Hierarchical Systems Engineering Vee



integrated program cost affordable. Be sure you address each of the topics identified here. Although you may be tempted to assume away the impacts an international partner can have on your strategy, don't ignore this potentially significant affordability driver. To get better insight into international impacts on affordability, refer to Craig Mallory's article on international programs.



How Do We Know What It Is and If It Will Work?

The System Engineering Plan (SEP) is the joint program manager and systems engineer document, but don't let the rest of your program team side step their responsibility to make their inputs/edits, because systems thinking is a collaborative team sport. This is the program manager's document outlining how he/she, along with the chief systems engineer, will invoke engineering discipline in the program and involve the entire team in delivering the required capability. This document encompasses the three Decomposition and Definition activities and the three Realization and Assessment activities and describes the processes used to connect them as depicted in Figure 1. The program manager and the chief systems engineer should:

- Lay out the clear plan for the technical architecture, the demarcation of the interfaces, and at what levels the configuration and interfaces will be managed.
- List necessary trade studies and analysis efforts.
- Describe expectations regarding engineering teams working and sharing information.
- Describe how technical progress will be assessed, including long-term performance (read sustainment, including reliability growth and maintainability improvements).
- Identify how production readiness and producibility are tracked.
- Address the approach to manage/insert new technology into the program.
- Describe staffing requirements necessary to execute this effort.

Why? Each one of these areas affects the program's affordability. But the key aspect of a SEP is the planned trade studies and analysis. Properly planning and then driving these trade studies into the program will have dramatic effects on a program's affordability decisions, through the use of decision-quality data. Understanding the direction and intent for these studies invokes a self discipline and, therefore, a program decision analysis discipline for the entire collaborative team. There are two articles in this very issue of *Defense AT&L* that might help you in your SEP writing efforts. The first is Brian Brodfuehrer's article on program metrics, to help you understand how to technically assess the program's progress, and second is a team article on effectively managing the transition to production by Dusty Schilling and Pete Czech.

How Long Do You Want to Operate?

The Life Cycle Sustainment Plan (LCSP) lays the foundation for long-term affordability. Program managers and engineers: Put your loggies/sustainers on speed dial—really. Expect engagement by your logistics manager on this plan; get those sustainer ideas on all aspects of the program. If sustainers are silent or unheard until you walk through the realization and assessment efforts, you can be sure life cycle affordability is in jeopardy.

Make sure those logistics managers bring their financial manager and contracting friends, because this plan needs good cost estimating and critical thinking about how it will be implemented in the contract and/or with organic capability. I refer you to Mark Husband's article on cost estimating. Engineers often believe a material or software solution is best, but a human process works just fine. I have generally found loggies balance these perspectives and generate more holistic and workable solutions.

By the way, did you notice at the bottom of the "Vee," under "Implementation," there are the words "Tech Data & Training Pubs" alongside "Hardware Fabrication" and "Software Creation/Coding?" Procurement of data rights for our systems can be a key to both long-term system sustainment and affordability. See Dave Gallop's article on the technical data decision process. Sure seems both engineers and loggies need to be involved through the Decomposition and Definition effort as well as through the Implementation and into the Realization and Assessment efforts. The LCSP is not just the sustainer's plan; it belongs to the program manager and the engineers as well. More importantly, it is driven by how the AS indicates the capability will be sustained across the life cycle.

Have you ever noticed how loggies and engineers think the same? Well, they generally don't. Engineers like black and white; loggies like "what abouts" and "what ifs."

The LCSP focuses engineers and loggies on a common thought: "How will this capability keep working long after we have all left the program?" And more importantly, "How will it stay sustainable and affordable throughout its expected life?" For a better understanding of sustainment, I refer you to Bill Kobren's article.

I Can Prove It

The Test and Evaluation Master Plan (TEMP) lays the foundation for a disciplined process of early and timely confirmation the capability DoD expects will work. You have heard the adage, "Bad news does not get better with time." What the unknown author really meant was, "The later you find out things don't work, the higher the ultimate price tag." Said another way, "The desired capability becomes increasingly unaffordable."

Nobody really likes to be tested, but that is exactly what moving up the right side of the systems engineering "Vee" and into the Realization and Assessment efforts does. The TEMP establishes how we will confirm to everyone involved that what is being purchased has the desired capability. The TEMP is the proverbial "Iron sharpens iron, so one man sharpens another" document. Knowing the program will be tested makes engineers and loggies do their respective tasks better. Knowing tests are resource intensive (read expensive) makes program and financial managers sharpen their funding allocations. Understanding the answers to the test questions (documented requirements) makes the requirements expectations clearer.

You did notice the horizontal lines between the three Decomposition and Definition activities and the three Realization and Assessment activities to the right? A good test and evaluation effort drives the ultimate in decision-quality data. Have I said yet the TEMP is a team document? It drives the cost by virtue of its existence and the weaknesses it finds, but it can also help confirm a program's capability and frame its affordability. For more insight into improving affordability through better testing, refer to Mike Bohn's article. A great advantage of systems engineering discipline is the early involvement by the test manager in a program.

Planning Allows Graceful Execution

All four of these documents remind every engineer in that middle part of the "Vee," the "Decomposition and Definition" as well as the "Realization and Assessment" effort, just exactly how to make decisions with cost, and thus affordability, as a foundation. They all chart the program course and/or consistently remind everyone involved in executing the program that affordability is at the forefront of each decision point along the path to delivering the product. But just as critically, they help your senior stakeholders determine if the nation's wealth is being well spent. So the next time you see the simple systems engineering "Vee" model, know it is the guide book to successful planning and execution of a program, and your secret weapon to successful delivery of an affordable capability driven by decision-quality data.

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